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Indian Standard

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पोर्टेबल इलेक्ट्रिक इंडोर एयर प्यूरीफायर — विशिष्टि

Portable Electric Indoor Air Purifier — Specification

ICS 13.040.20

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Air Quality Sectional Committee, CHD 35

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Air Quality Sectional Committee had been approved by the Chemical Division Council.

Emissions from industrial sources and from community waste dumping grounds alter the composition and constituents of air. In addition to this there are several sources of pollution inside households, such as smoke released during cooking, burning of incense sticks or mosquito coils and smoking. All these directly impact the health as well as the day to day performance of people.

Portable electric indoor air purifiers refer to purifiers used in residences and office spaces for cleaning air. These purifiers have become a common household appliance with growing air pollution levels in urban areas. Indoor air purifiers use a variety of mechanisms for reduction of pollutants present in indoor air so that people can breathe clean air and the environment is healthier.

The performance of air purifiers vary depending upon their size, technology, and power input. This standard prescribes some essential performance requirements for indoor air purifiers and describes the associated test methods. Hence, this standard is important to assess the quality of indoor air purifier.

In the preparation of this standard, considerable assistance has been derived from the following standards and documents:

[1] ANSI/AHAM AC-1 : 2015 Method for measuring performance of portable household electric room air cleaners.

[2] NF B44-200 : 2016 Independent air purification devices for tertiary sector and residential applications — Test methods — Intrinsic performances.

[3] IEC/FDIS 63086-1 Household and similar electrical air cleaning appliances — Measurement of performance — Part 1: General requirements.

[4] Draft IEC 63086-2-1 Household and similar electrical air cleaning appliances — Methods for measuring the performance.

[5] GB/T 18801 : 2015 Air Cleaner.

Bibliography is given in Annex E and the list of committee members and experts who have actively contributed and participated in the development of this standard is given in Annex F.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

PORTABLE ELECTRIC INDOOR AIR PURIFIER — SPECIFICATION

1 SCOPE

This standard prescribes the performance requirements, and methods of test for portable electric indoor air purifiers and for the air purification function of combination devices.

NOTES

1 This standard is not applicable to:

a) appliances intended exclusively for industrial purposes;

b) appliances intended for use in medical treatment locations, such as surgical suites, laboratories, medical treatments rooms, etc.' and

c) appliances intended for use inside vehicles.

2 The test method prescribed in this standard has defined limits of measurability based on the statistical accuracy of the method. Limits of measurability is explained in Annex A.

2 REFERENCES

The following standards contain provisions which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below:

IS No./IEC No./ ISO No.	*Title*
IS 302 (Part 1) : 2008	Safety of household and similar electrical appliances: Part 1 General requirements (*sixth revision*)
ISO 3743-2 : 2018	Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering methods for small, movable sources in reverberant fields — Part 2: Methods for special reverberation test rooms
ISO 21501-1 : 2009	Determination of particle size distribution — Single particle light interaction methods — Part 1: Light scattering aerosol spectrometer
IEC 60335-2-65 : 2002 + AMD1 : 2008 + AMD2 : 2015	Household and similar electrical appliances — Safety — Part 2 – 65 : Particular requirements for air-cleaning appliances
IEC 60704-1 : 2010	Household and similar electrical appliances — Test code for the determination of airborne acoustical noise — Part 1: General requirements
IEC 62301 : 2011	Household electrical appliances — Measurement of standby power

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply:

3.1 Portable Electric Indoor Air Purifier — Electrically powered device that is basically built of a set of components possessing the ability to capture and/or partially or totally destroy air pollutants for cleaning air in a room. Such purifiers can be moved from room to room.

3.1.1 *Air Purifier – Floor Type* — Floor type air purifiers are designed to stand on the floor of a room.

3.1.2 *Air Purifier – Table Type* — Table type air purifiers are designed to set on a table or counter.

3.1.3 *Air Purifier – Wall Type* — Wall type air purifiers are designed such that they can be mounted on a wall.

NOTE — A wall type air purifier must include proper wall mounting brackets and instructions to mount the air purifier integrally to the wall.

3.1.4 *Air Purifier – Multi-placement Type* — Multi-placement type air purifiers are designed to operate in one or more orientations/positions (floor, table, wall).

3.2 Combination Products — Air purifier that includes a secondary function besides air cleaning within the same machine, such as humidifying, dehumidifying, heating, or air conditioning.

3.3 Gas Concentration — Parts per billion volume, in ppbV.

NOTE — Formula to convert $\mu g/m^3$ to ppbV:

$$ppbV = \frac{\mu g}{m^3} \times \frac{1}{Molecular\ Weight_{contaminant\left(\frac{g}{mol}\right)}} \times 8.3144 \left[\frac{L.kPa}{mol.K}\right] \times T_{air}\left[K\right] \times \frac{1}{P_{air}\left[kPa\right]}$$

3.3.1 *Initial Concentration* — The gas concentration in the test chamber at the start of test time (t = 0).

3.3.2 *Background Concentration* — The gas concentration in the test chamber prior to introduction of known concentration of gas in the chamber.

3.4 Particle Concentration — Number of particles per cubic cm (cc) of room air.

3.4.1 *Initial Concentration* — The particulate number concentration at the start of test time (t = 0).

3.4.2 *Background Concentration* — The particulate number concentration in the test chamber prior to introduction of known concentration of particulate in the chamber.

3.5 Aerosol — Suspension of fine solid particles or liquid droplets in air or another gas.

3.5.1 *Smoke Aerosol* — Aerosol produced by burning cigarette tobacco with air forced through the cigarette's filter.

3.5.2 *Salt Aerosol* — Aerosol produced by atomization of an aqueous potassium chloride (KCl) or sodium chloride (NaCl) solution with subsequent drying.

3.5.3 *Dust Aerosol* — Aerosol produced by dispersion of commercially available test dust.

3.5.4 *Pollen Aerosol* — Aerosol produced by dispersion of particulate matter naturally occurring from plants, for example, commercially available paper mulberry pollen (non-defatted) including fragments.

3.6 Standby Condition — The state in which the air purifier is connected to the power supply, connected with a network (if applicable) and its display function is on (if applicable) but its other functions are off.

3.7 Standby Power — Input power of air purifier in the standby condition.

3.8 Natural Decay — Reduction in pollutant concentration due to natural phenomena, such as agglomeration, surface deposition (including sedimentation), chemical reaction, and air exchange.

3.9 Total Decay — Reduction in pollutant concentration due to natural decay combined with the action of air purifier.

3.10 Clean Air Delivery Rate (CADR) — Clean Air Delivery Rate (CADR), expressed in m^3h^{-1}, is defined as the measure of the delivery rate of purified air by an air purifier. CADR is calculated by subtracting the natural decay rate constant from the total decay rate constant and multiplying the difference by the volume of test chamber, as measured in m^3. CADR calculation is independent of technology used in air purifier for contaminant removal. *See* Annex B for calculation of CADR.

3.11 Air Exchange Rate — The number of times the total volume of air in a room changes in an hour due to natural ventilation.

NOTE — Natural ventilation means cross air ventilation in a room without the aid of any electrical/mechanical equipment.

3.12 Room Size — Maximum recommended room size for effective air purification by an air purifier. *See* Annex C for calculation of room size.

3.13 Maximum Performance Operation Mode — Manual operation mode where the purifier is set to the highest flow rate with all air cleaning functions switched on and set to maximum, where applicable.

NOTE — If the purifier has zero flow rate, the CADR is measured with all air cleaning functions switched on.

3.14 Energy Efficiency in Maximum Performance Operation Mode (η) — Volume of clean air delivered by consuming a certain amount of energy; calculated by dividing CADR by electrical power input and expressed in $m^3W^{-1}h^{-1}$.

4 PRINCIPLE OF PURIFICATION

A normal household/office room has a variety of pollutants in the air. Some of these pollutants include VOCs, dust, particulate matter, pollens, pet hair, odour, and microorganisms. Indoor air purifiers apply different methodologies for the removal of these pollutants.

4.1 Passive Purification System

Uses a train of media/filters to trap pollutants from the air which is drawn into the unit.

4.1.1 *High Efficiency Particulate Air (HEPA) Filter*

It is made out of technical textile which is randomly arranged, folded and boxed. They come in different classes and types [*see* IS 16753 (Part 1)].

NOTE — The highest class is H14, which offers efficiency of 99.97 percent for 0.3 micron particle.

4.1.2 *Adsorption*

The phenomenon in which molecules of pollutant (the adsorbate) are taken up and held on the surface of another material (the adsorbent).

4.1.3 *Ultra Low Particulate Air (ULPA) Filter*

This filter media can arrest at least 99.99 percent of dust, pollen, mould, bacteria and any airborne particles with a size of 100 nanometres (0.1 µm) or larger from the air.

4.2 Active Purification System

Uses technology to emit ions into the room space. When particulate matters come in contact with these ions, they react and the particles are charged. The charged particles coalesce to form large particles, which fall down due to increase in weight. When virus or pathogen come in contact with these ions, they might become inactive.

5 PERFORMANCE REQUIREMENTS

5.1 Clean Air Delivery Rate (CADR)

The CADR values shall be measured for each test pollutant given in **5**, at the maximum performance operation mode of the purifier as per the method given in Annex B, and shall be declared.

5.2 Capacity of Air Purifier and Room Size

The capacity of the air purifier in terms of room size shall be calculated using CADR for cigarette smoke/salt aerosol as per the method given in Annex C, and shall be declared.

5.3 Noise Level (Sound Power Level)

The sound power level of the purifier at the maximum performance operation mode, with cigarette smoke/salt aerosol as test pollutant, can be tested as per IEC 60704-1 or ISO 3743-2, and shall conform to the following table:

CADR (m^3h^{-1})	**Sound Power Level [dB(A)]**
≤ 150	≤ 55
$150 < \text{CADR} \leq 300$	≤ 61
$300 < \text{CADR} \leq 450$	≤ 66
$450 <$	≤ 70

NOTE — IEC 60704-2-XX is being developed for determination of airborne acoustical noise for air purifiers.

5.4 Power Consumption

The power consumed by the air purifier at the maximum performance operation mode shall be measured as per procedure given below, and shall be declared as the power input. Tolerance as per Table 1 of IS 302 (Part 1) allowed.

5.4.1 *Condition of Measurement*

The measurement of power consumption can be conducted simultaneously with the CADR test for cigarette smoke/salt aerosol.

5.4.2 *Conditioning of Air Cleaner*

Before carrying out the test, the air purifier motor shall be properly conditioned by running the air purifier continuously for 48 h with/without filters. If the air purifier is conditioned with filters, the filter needs to be replaced before starting the test.

5.4.3 *Procedure*

After conditioning of the motor, fully assemble the air cleaner with all filters and connect the power measuring instrument between the power supply and the air purifier. Switch on the air purifier, run it at the maximum performance operation mode and reset the power measuring instrument. Wait for 2 min and then start taking power readings every 1 min for 15 min.

5.4.4 *Calculation*

Take an average of the 15 power readings to obtain the power consumption of the air purifier at maximum performance operation mode. Upto 3 of the 15 readings may be discarded as anomalous if caused by potential line surges or other variables.

5.5 Standby Power

The standby power of the air purifier shall be less than or equal to 2.0 W when measured in accordance with IEC 62301.

5.6 Safety

The air purifier shall conform to safety requirements prescribed in IEC 60335-2-65.

6 TEST POLLUTANTS

6.1 Formaldehyde

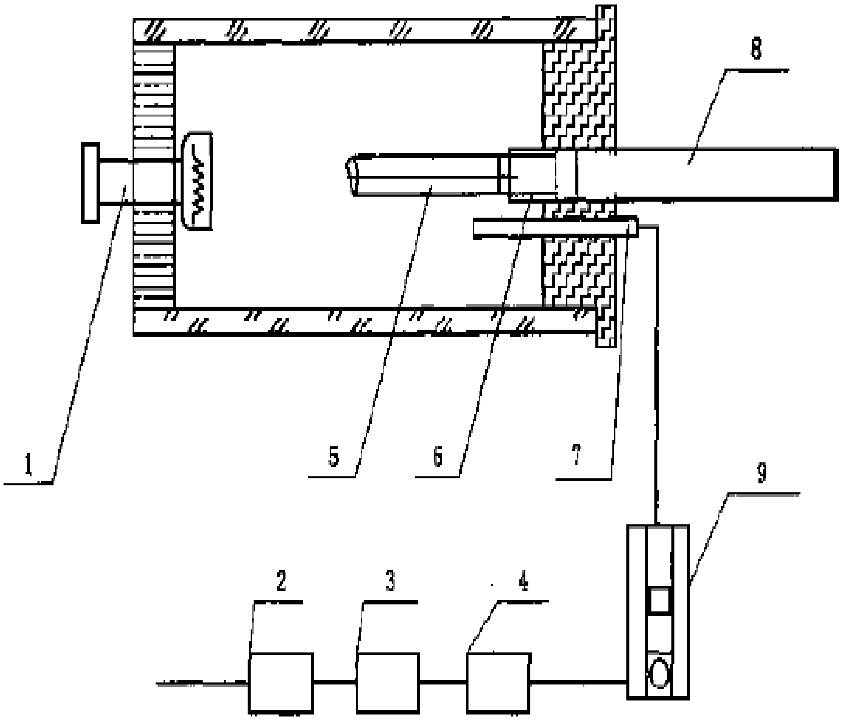
Formaldehyde gas standards certified from any National Metrological Institute (NMI) or laboratory traceable to NMI.

6.2 Toluene

Toluene gas standards certified from any National Metrological Institute (NMI) or laboratory traceable to NMI.

6.3 Cigarette Smoke/Salt Aerosol

Polydisperse smoke particles in the size range of 0.3 to 1.0 µm can be generated by lighting a cigarette in a chamber and forcing air through the cigarette's filter. An example of a generation device is shown in Fig. 1, other equivalent generation modes may be used.



1 cigarette lighter
2 oil-water separator
3 particulate filter
4 reducing valve
5 test cigarette
6 cigarette holder
7 air import tube
8 smoke export tube
9 air flowmeter

FIG. 1 EXAMPLE OF CIGARETTE SMOKE GENERATOR[7]

Polydisperse salt aerosol in the size range of 0.3 to 1.0 µm can be generated by atomizing NaCl or KCl solution. *See* Annex D for example of atomization procedure.

6.4 Dust

Certified Reference Materials (CRMs) from any NMI or commercially available test dust certified from NMI or lab traceable to NMI, in the size range of 1.0-5.0 µm.

6.5 Pollen

CRMs from any NMI or commercially available non-defatted paper mulberry pollen certified from NMI or lab traceable to NMI, in the size range of 5 to 11 µm.

7 APPARATUS

7.1 Temperature Sensors — With an accuracy of ± 0.5 ºC, calibrated from NMI or any laboratory traceable to NMI.

7.2 RH Sensors — With an accuracy of ± 2 percent RH, calibrated from NMI or any laboratory traceable to NMI.

7.3 Stopwatch — With an accuracy of ± 1 s in 24 h.

7.4 Aerosol Generator — Required to disseminate the cigarette smoke particles/salt/dust/pollen in the air inside the test chamber.

7.5 Atomizer — Instrument capable of generating particle sizes in the range of 0.3 µm to 1.0 µm.

7.6 Ceiling Fan — At the centre of the test chamber.

7.7 Laser Source Optical Particle Counter — To determine particle count of individual aerosol particles in the range of 0.3 µm to 11 µm with lower detection limit of 0.1 µm. The counting efficiency of the particle counter shall be ≥ 50 percent for 0.3 µm particles.

7.7.1 The sizing resolution of the particle counter shall be ≤ 8 percent (standard deviation/mean) and shall be measured in accordance with ISO 21501-1. The resolution shall be measured at a particle size in the 0.5 µm – 0.7 µm size range.

7.7.2 The optical particle counter shall have a minimum of 12 logarithmically spaced particle size channels. There shall be a minimum of three particle size channels in each of the following size ranges: 0.3 µm to 1.0 µm, 1.0 µm to 5.0 µm, and 5.0 µm to 11.0 µm. Particle size channel boundaries shall be located at 0.3 µm, 1.0 µm, 5.0 µm, and 11.0 µm.

7.7.3 The optical particle counter shall be calibrated in accordance with ISO 21501-1 from NMI or any standard lab traceable to NMI. The calibration shall be performed with monodisperse NMI-traceable polystyrene latex (PSL) spheres and the calibration shall include at least one particle diameter in each of the ranges of 0.3 µm – 0.4 µm, the upper most size channel, and at least four other sizes in between. The particle size calibration of the optical particle counter shall be performed at least annually.

7.8 VOC Analyzer — Spectrometry-based instrument to determine the concentration of formaldehyde and toluene, with lower detection limit of 1 ppbV. It shall be calibrated from NMI or any standard lab traceable to NMI.

7.9 CO_2 Detector — With accuracy of ± 3 percent of reading or ± 50 ppm, whichever is higher. The resolution shall be 1 ppm.

7.10 Power Measuring Instrument — Capable of measuring true RMS watts, with accuracy of ± 1 percent at rated voltage and frequency, and resolution of minimum 0.01 watts.

NOTE — Aerosol generators and analyzers should be calibrated from standard laboratory traceable to NMI.

8 GRADING

The air purifiers are classified into the following grades based on their energy efficiency when tested at maximum performance operation mode using cigarette smoke or salt aerosol as test pollutant.

8.1 Grade I

$$\eta \geq 10\ m^3 W^{-1} h^{-1}$$

8.2 Grade II

$$6\ m^3 W^{-1} h^{-1} \leq \eta < 10\ m^3 W^{-1} h^{-1}$$

8.3 Grade III

$$\eta < 6\ m^3 W^{-1} h^{-1}$$

9 PACKING

The air purifiers shall be packed in good quality boxes with appropriate cushioning so that the purifier doesn't get damaged during transportation.

10 MARKING

10.1 The air purifier shall have the following information marked in a permanent and legible manner in a location where it is accessible and visible:

a) Name or trademark of the manufacturing/assembling unit;

b) Type or model number and serial number of the unit;

c) Rated voltage and rated frequency;

d) Power input in W at rated conditions;

e) CADR for cigarette smoke or salt aerosol at maximum performance operation mode;

NOTE — CADR for all test pollutants (*see* **5**) to be declared in the product manual.

f) Sound power level in dB(A) at maximum performance operation mode; and

g) Grade of the air purifier (Grade I, Grade II, and Grade III).

10.2 The information specified at **10.1 (a)** to **(g)** shall also be marked on the packaging box. However, the serial number of the unit need not be marked on the packaging box.

10.3 BIS Certification Marking

The product(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the products may be marked with the Standard Mark.

11 MANUFACTURER'S GUARANTEE

11.1 The manufacturer shall give a guarantee for the soundness of construction and performance of the air purifier, and shall be responsible for putting right any manufacturing defects free of charge for a period of at least twelve months right from the date of sale to the original purchaser or date of inspection of approval in the case of Government and Semi Government institutions. Such repairs or replacements of defective parts shall be carried out at manufacturer's works or by its authorized agent at site or at a service shop.

11.2 The manufacturer shall provide instructions with details of maintenance requirements and frequency of changing replaceable components. Preferably, visual indications may be provided to signal replacement of filters.

11.3 Precautionary instructions for installing, using, and maintaining the air purifier shall be provided to the consumer.

ANNEX A

(*Clause* 1)

LIMITS OF MEASURABILITY

This standard method has defined limits of measurability based on the statistical accuracy of the methods.

The maximum CADR values are determined based on theoretical maximum limits. The theoretical maximum limits are determined by the maximum number of initial available particles, the acceptable minimum number of available particles, an average background natural decay rate (from statistical study), the size of the test chamber, and the available minimum experiment time. CADR values for dust, cigarette smoke/salt and pollen greater than those listed will not have the necessary statistical data required by this method. CADR values for pollen approaching that listed are normally determined by pooling of the test value data determined under this method. Therefore, the standard only applies to air purifiers with maximum CADR ratings of:

Dust CADR = 690 m^3h^{-1}

Cigarette smoke/salt aerosol CADR = 768 m^3h^{-1}

Pollen CADR = 768 m^3h^{-1}

The precision of the standard as based on a 0 CADR air purifier expressed as 2 standard deviation limits (95 percent) are:

Dust CADR = ± 18 m^3h^{-1}

Cigarette smoke/salt aerosol CADR = ± 18 m^3h^{-1}

Pollen CADR = ± 26 m^3h^{-1}

ANNEX B

(*Clause* 5.1)

DETERMINATION OF CLEAN AIR DELIVERY RATE (CADR)

B-1 STRUCTURE OF TEST CHAMBER

The CADR of an air purifier device is evaluated in a test chamber. The test chamber is divided into two sections:

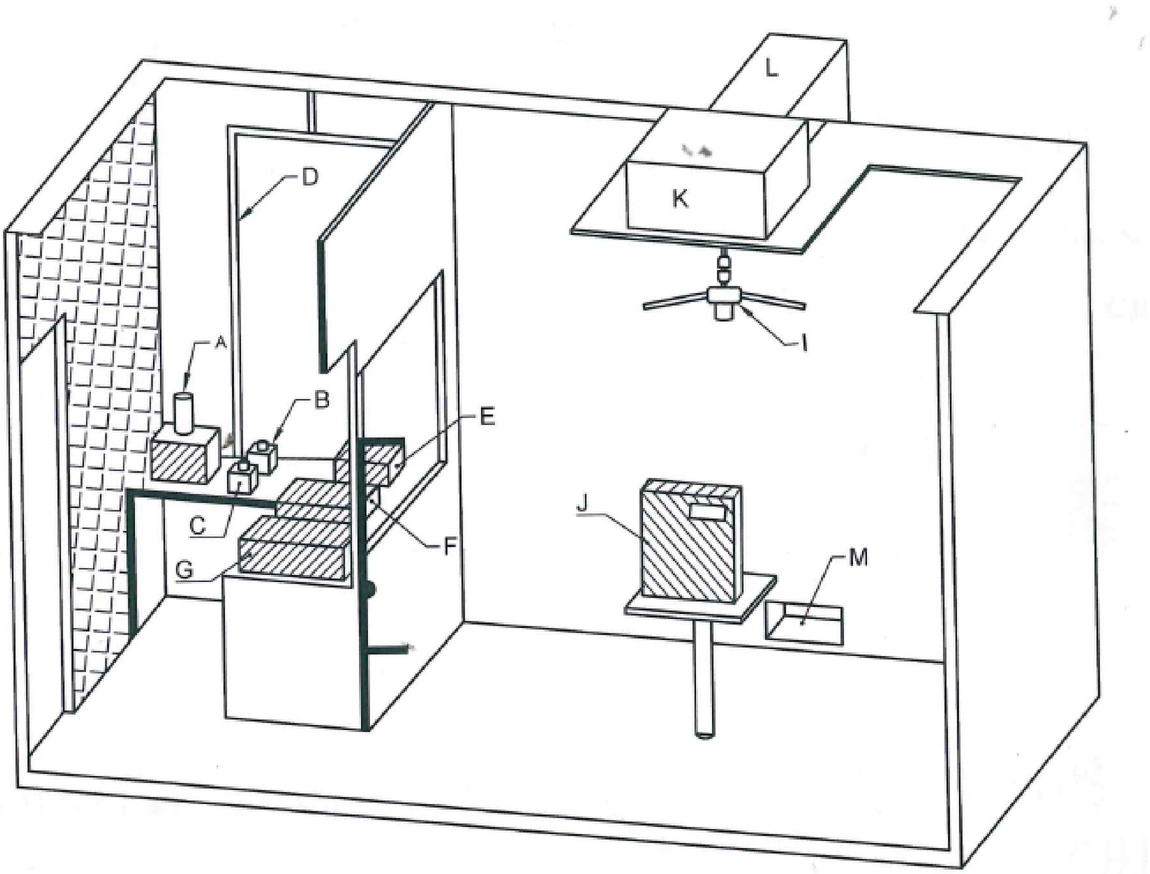
a) Observation section; and

b) Test section.

In the observation section, all particles/gas analysers, particle generators (cigarette smoke/salt, dust and pollen particle generator) and gas cylinders are placed. In the test section, CADR testing is carried out. The schematic of the test chamber is given in Fig. B-1. The dimensions and details of test section are given in Table B-1.

Table B-1 Specifications of Test Section

Items	Parameters
Interior volume	(30 ± 1.5) m^3
Interior dimensions	Height = (2.5 ± 0.1) m The width shall be within 85 – 100 percent of the length.
Temperature and humidity	Test shall be carried out without the influence of outside air, sunlight and other radiation effects. Temperature shall be maintained at (25 ± 2) ºC and relative humidity at (50 ± 10) percent RH.
Surfaces	All surfaces shall be low-adsorptive, chemically inert, non-corrosive, easy to clean, and with sufficient structural integrity. Recommended material for the walls, ceiling, and floor: stainless steel AISI grades 304, 310, or 316, glass or equivalent. All conducting surfaces shall be grounded.
Sealing material	Welding, silicon rubber strip material, and low emission glass sealant may be used, where necessary
Ceiling fan	The ceiling fan shall have a diameter between 1.0 and 1.4 m with three blades and a minimal airspeed of 1 m/s. The air speed shall be measured 0.5 m below the fan blade's surface and laterally half way between the central axis and the blade's tip. Installation location: on the ceiling, in the centre of the test chamber, with the distance of the highest point on the blades to the ceiling's surface between 0.25 m and 0.5 m.
Test section air treatment unit	The test section air treatment unit shall be used for conditioning of the air (that is, temperature, humidity), and filtration of the target pollutant. It may be operated in recirculation mode or supply fresh air from the external environment.
Leakage rate	The air leakage rate shall be not greater than 0.05 h^{-1} according to the measurement procedure described in **B-4**.



Key:

(A, B, C) – Particle Generators

(D) Inlet line for test pollutant

(E) Optical particle counter

(F) CO_2 detector

(G) VOC analyser

(H) Analyser inlet/Sampling line with two way valve

(I) Ceiling fan

(J) Test air purifier

(K) Blower section (with pre/HEPA filter)

(L) Chamber return air unit

(M) Return air dampner

FIG. B-1 SCHEMATIC OF TEST CHAMBER FOR CADR MEASUREMENT

B-1.1 The VOCs, cigarette smoke/salt particles, dust, and pollen are dispersed above the ceiling fan through a delivery line and injection port.

B-1.2 The air purifier under test is placed in the middle of the test chamber. The air purifier may be placed either on the floor or on the table (0.7 m in height), as per its design (*see* **3.1.1** to **3.1.4**). If it is a wall type air purifier, provision shall be made to keep it in a stable position at the centre of the room, on a table or stand at a height of 0.7 m.

B-1.3 For the measurement of particles and gases, samples are taken from 2 sampling ports, which are placed at a height of 0.6 m and 1.5 m above the floor. The samples collected through these ports are analysed by the respective particle counters and gas analysers. For air purifiers which discharge air in a specific direction, the air discharge shall not be pointed toward the sampling ports.

B-1.4 Temperature and humidity inside the test section is constantly monitored using 4 temperature and 4 RH sensors placed at 4 corners of the chamber. Temperature and humidity values outside the prescribe range invalidate the tests.

B-2 TEST PROCEDURE

B-2.1 Test Voltage and Frequency

The test shall be carried out at the rated voltage and frequency of the air purifier ± 1 percent throughout the duration of the test.

B-2.2 Initial Concentration

The initial concentration of the test pollutants shall be as per limit prescribed below:

a) Formaldehyde: 100 ppbV
b) Toluene: 100 ppbV
c) Cigarette Smoke/salt aerosol: 24 000 to 35 000 particles/cc (diluter may be required)
d) Dust: 200 to 400 particles/cc
e) Pollen: 4 to 9 particles/cc

B-2.3 Background Concentration

This is the allowable level of pollutant concentration in the test section prior to the introduction of the test pollutant. Using the test section air treatment unit, allow the test section air to clean until the background concentration reaches a level below the values indicated:

a) Formaldehyde: 10 ppbV
b) Toluene: 10 ppbV
c) Cigarette Smoke/salt aerosol: 20 particles/cc
d) Dust: 0.03 particles/cc
e) Pollen: 0.03 particles/cc

B-2.4 Test Procedure for Calculating Natural Decay

B-2.4.1 Keep the air purifier switched off and switch on the ceiling fan. The chamber air is circulated out by air dampner (M) through air filtration system or air treatment unit (K). The filtration system consists of prefilter (to remove coarser particles) and HEPA filter (to remove fine and ultrafine particles). Recirculation of chamber air should be continued from dampner (M) to filtration system (K) for sufficient period of time with constant monitoring of particle count and gas concentration till nominal background concentration (*see* **B-2.3**) is achieved. Record the background concentration.

B-2.4.2 Turn off the filtration system (dampner, blower and HEPA filter), whereas the ceiling fan shall be kept operative. The test pollutant is now introduced in the test section. The ceiling fan circulates the pollutant uniformly throughout the room. Once the initial concentration of pollutant reaches the range prescribed in **B-2.2**, the inlet is closed. The ceiling fan is operated for one more minute and then switched off.

After switching off the ceiling fan, begin to acquire the concentration after waiting time indicated in Table B-2. This value is the initial concentration and regarded as t = 0 in the calculations. If the initial concentration is not within the limits given in **B-2.2**, terminate the run.

Acquire concentration data at 1 min intervals for the time indicated in Table B-2. Minimum number of data points listed in Table B-2 having concentrations greater than the lower limit of instrument measurability are required.

Table B-2 Waiting Time, Test Duration and Minimum Number of Data Points

Aerosol	VOC	Cigarette Smoke/Salt Aerosol	Dust	Pollen
Waiting time* (min)	1	3	1	1
Test duration (min)	20	20	20	10
Minimum number of data points	9	9	9	5

*The waiting time before starting data acquisition starts to count as soon as the ceiling fan is switched off.

B-2.4.3 Calculate the natural decay constant as per **B-3.2**.

B-2.4.4 Calculate the standard deviation of the natural decay in accordance with **B-3.3**. A standard deviation of less than the 95 percent confidence limit of the values indicated in Table B-3 or 10 percent, whichever is greater, determines the acceptability of the run.

Table B-3 Limit for the Standard Deviation to Determine the Acceptability of the Natural Decay Measurement

Aerosol	VOC	Cigarette Smoke/Salt Aerosol	Dust	Pollen
Limit for standard deviation (min^{-1})	0.001	0.002	0.001	0.009

B-2.5 Test Procedure for Calculating Total Decay (with Air Purifier)

B-2.5.1 Repeat procedure given in **B-2.4.1**.

B-2.5.2 Turn off the filtration system (dampner, blower and HEPA filter), whereas the ceiling fan shall be kept operative. The test pollutant is now introduced in the test section. The ceiling fan circulates the pollutant uniformly throughout the room. Once the initial concentration of pollutant reaches the range prescribed in **B-2.2**, the inlet is closed. The ceiling fan is operated for one more minute and then switched off.

Wait for the waiting time indicated in Table B-2 and record the initial concentration (t = 0). Switch on the air purifier immediately after recording the initial concentration. Thereafter acquire concentration data at 1 min intervals for the time indicated in Table B-2. Minimum number of data points listed in Table B-2 having concentrations greater than the lower limit of instrument measurability are required. Also, if the initial concentration is not within the limits given in **B-2.2**, terminate the run.

B-2.5.3 Calculate the total decay constant as per **B-3.2**.

B-2.5.4 Calculate the standard deviation of the total decay in accordance with **B-3.3**. A standard deviation of less than the 95 percent confidence limit of the values indicated in Table B-4 or 10 percent, whichever is greater, determines the acceptability of the run.

Table B-4 Limit for the Standard Deviation to Determine the Acceptability of the Total Decay Measurement

Aerosol	VOC	Cigarette Smoke/Salt	Dust	Pollen
Limit for standard deviation (min^{-1})	0.003	0.008	0.003	0.0022

B-2.5.5 Determine CADR of the air purifier as per **B-3.4**. Convert the CADR to m^3h^{-1} units as per **B-3.6**.

B-2.5.6 Calculate the standard deviation of the CADR in accordance with **B-3.5**. A standard deviation of less than the 95 percent confidence limit of the values indicated in Table B-5 or 10 percent, whichever is greater, determines the acceptability of the run.

Table B-5 Limit for the Standard Deviation to Determine the Acceptability of the CADR Measurement

Aerosol	VOC	Cigarette Smoke/Salt	Dust	Pollen
Limit for standard deviation (min^{-1})	17	15	17	39

B-3 CALCULATION

B-3.1 Criteria for Elimination of Data Points

The data points recorded shall be eliminated if any of the following errors occur while recording data:

a) Operator error,
b) Equipment error,
c) Data point outside 95 percent prediction limit of regression line calculated in **B-3.3**, and
d) Data point lower than the LDL of measuring instrument.

B-3.2 Calculating Natural and Total Decay Constant of Pollutant

The decay constant, k, for the pollutant is based on the formula:

$$C_{ti} = C_i e^{-kti} \qquad ...(1)$$

where

C_{ti} = concentration at time t_i;
C_i = initial concentration;
k = decay constant (min^{-1}); and
t_i = time (min).

The decay constant is obtained by the linear regression of ln C_{ti} and t_i using the formula:

$$k = \frac{S_{XY}}{S_{XX}} \qquad ... (2)$$

where

$$S_{XY} = \sum\nolimits_{i=1}^{n} t_i lnC_{ti} - \left(\frac{1}{n}\right)\left(\sum\nolimits_{i=1}^{n} t_i\right)\left(\sum\nolimits_{i=1}^{n} lnC_{ti}\right) \qquad ...(3)$$

$$S_{XX} = \sum\nolimits_{i=1}^{n} (t_i)^2 - \left(\frac{1}{n}\right)\left(\sum\nolimits_{i=1}^{n} t_i\right)^2 \qquad ...(4)$$

where

n = no. of pairs of data points.

If the above calculations are used for natural decay measurements, the results represent the natural decay rate. If the above calculations are used for the total decay measurements, the results represent the total decay rate.

B-3.3 Calculation of Standard Deviation

B-3.3.1 *Standard Deviation of Regression Line*

Standard deviation about the regression line is calculated as follows:

$$S_{reg} = \sqrt{\left[\left(\frac{1}{n-2}\right)\sum\nolimits_{i=1}^{n}\left(lnC_{ti} - b - mt_i\right)^2\right]} \qquad ...(5)$$

where

S_{reg} = estimated value of overall standard deviation;
n = number of pairs of data points used in the regression;
b = intercept of the regression line;
m = slope of regression line, min^{-1};
t_i = time, in minutes; and
$ln\ C_{ti}$ = natural logarithm of concentration at time t_i.

B-3.3.2 *Standard Deviation of Regression Line Slope*

The standard deviation of regression line slope is calculated as follows:

$$S_{slope} = \sqrt{\frac{S_{reg}{}^2}{S_{XX}}} \qquad ...(6)$$

B-3.4 Calculation of CADR

The equation for calculating CADR is given below:

$$CADR = V(k_t - k_n) \qquad ...(7)$$

where

V = volume of test chamber (m^3);
k_t = total decay constant (min^{-1}); and
k_n = natural decay constant (min^{-1}).

B-3.5 Calculation of Standard Deviation of CADR

$$S_{CADR} = 30\sqrt{(S_{slope,kt})^2 + (S_{slope,kn})^2} \qquad ...(8)$$

where

S_{CADR} = standard deviation of CADR, m^3/min;

$S_{\text{slope,kt}}$ = standard deviation of total decay constant, min^{-1};

$S_{\text{slope,kn}}$ = standard deviation of natural decay constant, min^{-1}; and

30 volume of test section, m^3.

B-3.6 Conversion to m³/h

$$\text{CADR } (m^3/h) = \text{CADR } (m^3/min) \times 60 \qquad ...(9)$$

B-4 DETERMINATION OF THE LEAKAGE RATE OF THE TEST CHAMBER

B-4.1 Tracer Gas

Carbon dioxide (CO_2) is regarded as the tracer gas. The decay constant of the tracer gas in the test section is measured, which yields the leakage rate.

B-4.2 Sampling Point

The sampling ports (H) indicated in Fig. B-1 and clause **B-1.3** can be used. The sampling port shall be connected to a CO_2 measurement device outside of the test section. A continuous-reading measurement instrument shall be used.

B-4.3 Test Section Conditioning

Turn on the test section air treatment unit to reduce the background concentration of particulate matter (larger than 0.3 µm in diameter) to a level below 10^6 m^{-3}. Record the background concentration of CO_2 and start the temperature and humidity control device to set the temperature and relative humidity to the test section conditions specified in Table B-1.

B-4.4 Tracer Gas Introduction

Turn off the air treatment unit and turn on the ceiling fan. Turn on the tracer gas supply and introduce the gas into the test section. As soon as the concentration reaches a value greater than 4 000 ppm (parts per million), turn off the tracer gas supply and keep the ceiling fan on for another 10 min. After the tracer gas is completely mixed, turn off the ceiling fan.

B-4.5 Initial Concentration

Measure the initial concentration of the tracer gas CO_2, taking the time $t = 0$ in the later calculation.

B-4.6 Data Sampling

Record the concentration for at least 240 min.

B-4.7 Decay of Tracer Gas

$$C_t = C_0 e^{-kt}$$

where

C_t = the concentration of CO_2 at the time *t,* in ppm;

C_0 = the initial concentration of CO_2 at the time

t = 0 in ppm;

k = the decay constant, in h^{-1}; and

t = the time, in h.

B-4.8 Decay Constant

By linear regression of ln C_t as a function of t, the decay constant k is obtained by:

$$-k = \frac{\left(\sum_{i=1}^{n} t_i lnC_{t_i}\right) - \frac{1}{n}\left(\sum_{i=1}^{n} t_i\right)\left(\sum_{i=1}^{n} lnC_{t_i}\right)}{\left(\sum_{i=1}^{n} t_i^2\right) - \frac{1}{n}\left(\sum_{i=1}^{n} t_i\right)^2}$$

where

i = the index of the individual sample;

t_i = the time of the i-th sample; and

n = the total number of samples.

ANNEX C

(*Clause* 5.2)

DETERMINATION OF ROOM SIZE

C-1 The room size suitable for an air purifier is calculated considering steady state conditions in which the air purifier has the ability to reduce the concentration of cigarette smoke/salt aerosol in the size range of 0.3 – 1.0 µm to 80 percnt of the original value.

C-2 STEADY STATE CONDITIONS IN INDOOR

Sources of contaminant: Indoor sources + outdoor sources.

Removal of contaminant: Ventilation + deposition + air purifier

When no air purifier is working and the particle concentration is at steady state:

Sources = Ventilation + deposition

$$\text{Sources} = C\,(k_v + k_d) \qquad ...(10)$$

where, k_v is decay constant due to ventilation and k_d is decay constant due to deposition.

C-3 Assuming that after the air purifier is turned on a new steady state is achieved where the concentration of particles reduced by 80 percent:

$$\text{Sources} = 0.2C\,(k_v + k_d + k_{AC}) \qquad \text{...(11)}$$

C-4 Equating equations (10) and (11):

$$C\,(k_v + k_d) = 0.2C\,(k_v + k_d + k_{AC}) \qquad \text{...(12)}$$

Rearranging:

$$k_{AC} = 4\,(k_v + k_d) \qquad \text{...(13)}$$

Now, k_t (total decay constant) and k_n (natural decay constant) can be written as:

$$k_n = (k_v + k_d) \qquad \text{...(14)}$$

$$k_t = (k_v + k_d + k_{AC}) \qquad \text{...(15)}$$

Since, CADR = $V\,(k_t - k_n)$, thus,

$$\text{CADR} = Vk_{AC} = 4V\,(k_v + k_d) \qquad \text{...(16)}$$

Assuming an average ceiling height of 2.5 m in Indian households and offices:

$$A = \frac{CADR}{10(k_v + k_d)} \qquad \text{...(17)}$$

If the user is using air purifier for protection from pollutants in outdoor air, the user will close doors and windows. In such conditions, the ventilation rate may range from 0.05 – 0.57 h^{-1}. This situation also applies for winter season when doors and windows are kept closed to keep away wind and cold.

However, when the source of pollution is indoors, for example, cooking fumes, incense stick, dust etc., and the windows are open, the ventilation rate may be 1 h^{-1} or higher. Hence, assuming an average air exchange rate for houses in India as $k_v = 0.6\ h^{-1}$ and the average deposition rate for cigarette smoke/salt is $k_d = 0.2\ h^{-1}$, the area of the room can be calculated as follows:

$$A\,(m^2) = 0.125\ \text{CADR} \qquad \text{...(18)}$$

C-5 The above equation can also be used to determine the required CADR value if the room size is known.

ANNEX D

(*Clause* 6.3)

AEROSOL GENERATION

D-1 SALT AEROSOL

The salt aerosol shall consist of polydisperse solid-phase (dry) KCl particles generated from an aqueous KCl solution using a mass concentration of 5 percent. Figure D-1 gives an example of a system for generating the aerosol. It consists of a small container with the aqueous KCl solution and a Laskin nozzle. The salt aerosol is generated by feeding compressed particle-free air through the Laskin nozzle. The aerosol leaving the atomizer shall be dried below the efflorescence humidity of KCl to ensure a solid-phase aerosol. The dried salt aerosol is introduced into the test chamber. Varying the operating air pressure of the generator allows control of the time to reach the initial concentration.

NOTES

1 An aqueous KCl solution with a mass concentration of 5 percent corresponds to 52.6 g KCl per 1 l de-ionized water.

2 A silica gel diffusion dryer is recommended for drying the salt aerosol.

3 Short and electrically conductive tubes or hoses shall be used to minimize particle losses.

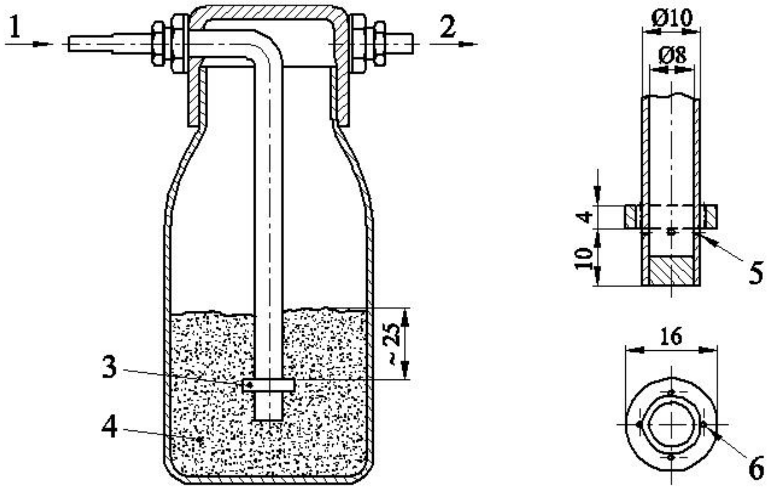
4 Any other generator capable of producing a salt aerosol in sufficient concentrations can be used, such as for example, collision nebulizers.

D-2 SMOKE AEROSOL

Take one test cigarette from the humidity chamber maintaining a temperature of (25 ± 2) °C and a relative humidity of (50 ± 10) percent for the long-term storage. Light the cigarette and place it in the cigarette smoke generator. Seal the smoke generator and turn on (2.4 ± 0.5) l/min air supply.

D-3 POLLEN AEROSOL

For generation of pollen aerosol, a 60 ml screw-top glass laboratory sample jar is sealed air tight with nominal 1/4 inch brass fittings for air entry and pollen discharge. Attach one of the pre-weighed paper mulberry pollen sample bottles to the pollen generator. To generate the aerosol, turn on the pollen generator air supply at 137 kPa for 10 s.



Key

1 Particle-free air inlet (pressure about 17 kPa)
2 Aerosol outlet to test chamber
3 Laskin nozzle
4 Liquid test aerosol
5 Four Ø 1.0 mm holes 90° apart top edge of holes and just touching the bottom of the collar
6 Four Ø 2.0 mm holes next to tube in line with the Ø 1.0 mm holes

FIG. D-1 SALT AEROSOL GENERATOR

ANNEX E

(*Foreword*)

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ANNEX F

(*Foreword*)

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